

Optical Transducer for Detecting Resonant Frequency and Free-End Amplitude of a Vibrating Reed (Low Driving Force)

In the vibrating reed or resonance method of mechanical dynamic testing the amplitude of vibration, as related to frequency, at the free end of the reed is a variable that is difficult to measure accurately. In one method of mechanical dynamic testing¹ the reed's free-end amplitude is measured at reed resonance and at discrete frequency increments above and below resonance. The transducer described in this note was designed to meet the above requirements. While inductance,² capacitance,³ and optical transducers⁴ have been successfully used for this work, the optical transducer has certain inherent advantages in regard to the detection of the free-end vibration of a reed. To sum up these advantages, the optical transducer does not add friction or mass and/or electrostatic or magnetic fields, all of which are possible sources of error and add a compensating factor to the measurements. In contrast, there is never any "factor" to be added to or subtracted from an optical transducer measurement.

Shadowing or occluding a light source of constant intensity is an obvious and widely used method of photoelectric detection. As an example, a method of varying the output of a photocell employing a shaped aperture and shadowing the source of incident light was employed by B. G. Leary in a study of textile yarns.⁵ On the other hand, a light intensity change of the source illumination also has an intrinsic advantage. The transducer described herein is a combination of these two approaches to photoelectric detection.

Essentially, the techniques employed in the design of this transducer consist of focussing a magnified image of a straight filament tungsten projection lamp onto a front surface mirror which in turn reflects the light of this image back toward a photovoltaic cell. Some degree of image magnification for the lamp filament is desirable, but the actual amount strictly is arbitrary. A second lens is used to focus an image of the illuminated front surface mirror onto the photo cell. In this case the magnification might just as well be unity for practical purposes. The filament image acts as the source of light for the photo cell and the light of this image is occluded by the reed sample. Since the edges of the filament image are irregular, the light return mirror is made to a definite rectangular shape, the long side of the rectangle being parallel to the filament. The mirror area is smaller than the image area, thus eliminating the fuzzy edges and giving a geometrically precise light source for the photocell to look at. This arrangement is analogous to a brightly illuminated slit, with the advantage that the projector and photocell are on the same side of the vibrating sample. The apparatus is illustrated in Figure 1.

In use, the light from the filament image is periodically

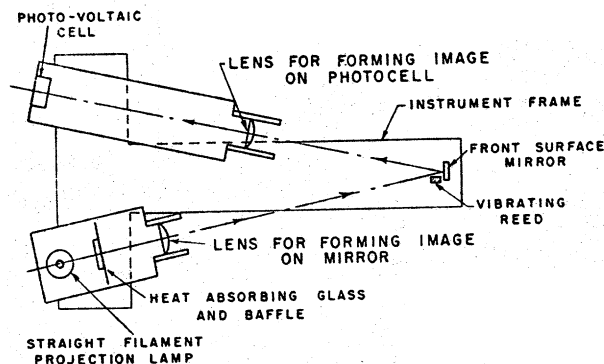


Fig. 1. Diagram of optical system.

occluded by the vibrating reed, resulting in corresponding light intensity change on the photocell. In this particular instance the occlusion is sinusoidal; therefore the photocell response will be sinusoidal. The photocell output is put into a sensitive oscilloscope. The oscilloscope trace will accurately show the resonant point of the reed. The free-end amplitude can be measured if the system is calibrated; also, frequency can be measured, depending on the characteristics of the oscilloscope.

The advantages of this transducer are: (1) as a result of the geometry and relative positions of reed and mirror, a large light change occurs for a small reed translation; (2) the reed being studied can be placed practically coincident with the plane of the most intense light concentration, with no ill effects on the sample, such as undesirable heating; (3) there is a minimum number of optical parts, no moving part, and only one electronic part, the photovoltaic cell; (4) the optical parts including the photocell are always in permanent, precise alignment; (5) the device can be very speedily applied and adjusted to the reed being studied; this includes the ability to "reach" into an environmentally controlled test chamber.

References

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